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TOURMALINE

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

TOURMALINE[1]

By I. Aitkens[2]

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INTRODUCTION

Tourmalines are among the most beautiful of all the semiprecious stones, and are unsurpassed even by corundum in variety of hue. The stones most suited to jewelry purposes are those comparatively free from iron. One reason for the fact that the tourmaline has advanced rapidly in public favor in this country is that it is found in California in great profusion and of extraordinary quality. The superb green and especially the pink crystals found at Pala and Mesa Grande in San Diego County, Calif., are deemed superior to tourmalines from all other localities.

DESCRIPTION AND PROPERTIES

Tourmalines are borosilicates of very complex composition. Authorities differ as to the correctness of the formula, but it is often written $R_{18}B_2(Si\ O_5)_4$, in which R may include lithium and other alkalies, magnesium, calcium, manganese, iron, and aluminum. Fluorine likewise may be present.

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[1] - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6539."

[2] - Rare metals and nonmetals division, U. S. Bureau of Mines.

The mineral is commonly found in well-developed, prismatic, vertically grooved or striated crystals of the hexagonal system. The crystals usually exhibit a rounded triangular outline, and different crystal forms are present at the opposite ends. This polar character is further evidenced by the electrical properties of tourmaline.

Tourmaline has no well-defined cleavage, and its fracture is from subconchoidal to uneven. It is optically negative and has a strong birefringence (0.020). Its mean index of refraction is near 1.63, and the dispersion is 0.016. The most prominent character of this mineral is its strong dichroism, and therefore stones are usually cut so that both of the dichroic colors may be seen as the stone is turned in various directions.

The hardness is about the same as quartz, from 7 to 7.5 on Moh's scale, but it is slightly heavier, the specific gravity ranging from 2.9 to 3.2. Tourmaline has a vitreous luster, and while the light colored stones are more or less transparent, the black and brown varieties are generally opaque. However, usually the tourmaline that is rich in alkalies is transparent and possesses most attractive colors. The varieties used as gems are achroite, colorless; Brazilian emerald, green; Brazilian peridot, yellowish green; Brazilian sapphire, blue; indicolite, dark blue; peridot of Ceylon, honey-yellow; rubellite, rose-red or pink; and siberite, violet. The iron tourmaline or schorl is black, and the magnesium tourmaline is brown.

In the alkali tourmalines the colors are frequently arranged in regular zones or bands. These zones may be horizontal, running across the crystals; or the colors may be arranged in vertical, somewhat cylindrical zones, parallel to the prism faces of the crystal. The typical arrangements of the colors, however, are as follows: Green at one end and red at the other, with a narrow colorless zone between; green followed by yellow, red, and green again; or, perhaps crimson or green tipped with black. In Brazilian stones the core is generally red, with a marginal zone of green and an intermediate colorless band; the southern California stones are usually green inside and red outside.

The following is a list of gem and trade names of the tourmaline mineral group:

Gem Name	Common Name or Description
Achroite	Colorless or white tourmaline.
Andalusite	Silicate of aluminum; also trade name for brown tourmaline.
Aphrizite	Black tourmaline.
Brazilian emerald	Green tourmaline.
Brazilian peridot	Yellow-green tourmaline.
Brazilian sapphire	Light-blue or greenish topaz; also blue tourmaline.
Ceylon chrysolite	Yellowish green or greenish yellow tourmaline.
Ceylon peridot	Honey-yellow or yellowish green tourmaline.
Dravite	Brown tourmaline.
Emeralite	Green and bluish green tourmaline from San Diego County, Calif.

Gem Name	Common Name or Description
Indicolite	Blue tourmaline.
Peridot of Ceylon	Same as Ceylon peridot, honey-yellow tourmaline.
Precious schorl	Tourmaline.
Rubellite	Pink and red tourmaline.
Schorl	Black tourmaline.
Siberian ruby	Red tourmaline.
Siberite	Violet-red tourmaline.

USES

The fact that tourmaline is soft and consequently not very durable discourages its use where it is likely to encounter hard wear. Although well suited for pendants, brooches, and like articles, the stone must be carefully protected by the setting when mounted in rings. It is admirably fitted for use in any article of jewelry in which a large central stone is required. In the cutting of gem tourmaline various styles are used. Occasionally it is sufficiently fibrous in structure to display, when cut "en cabochon," a pronounced chatoyancy (play of colors), but, like all colored stones, it is generally brilliant-cut in front and step-cut at the back.

Tourmaline is also used in the manufacture of tourmaline tongs and in measuring the intensity of radium emanations.

Ordinary black tourmaline usually has no commercial value but the Unite States Bureau of Mines has received one or two inquiries for small lots of a few pounds for experimental purposes, probably in connection with radio or other electrical work.

IDENTIFICATION

Tourmaline is recognized chiefly by the characteristic rounded triangular cross section of its crystals. It is easily distinguished from topaz, because the latter is about 30 per cent heavier than either tourmaline or quartz. Its range of refractivity, on the other hand, overlaps that of topa although the latter has a much smaller double refraction by which it may be distinguished readily. Unmounted stones are distinguished even more easily, because tourmaline floats in methylene iodide, whereas topaz sinks.

Another distinguishing feature of tourmaline is that it is strongly pyr electric, and when cooling after being heated it will develop positive electricity at one end of the crystal and negative at the other. It is also strongly dichroic, and light traversing the crystal in one direction may be quite a different color or shade of color from that traversing the crystal in a direction at right angles to the first.

SUBSTITUTES

Tourmalines are remarkable for certain optical properties which they possess and which render them practically incapable of being successfully imitated. However, there is little or no commercial advantage in manufacturing artificial tourmalines, due to their relatively low value and abundance in many localities.

HISTORY

Although tourmalines were no doubt known to the ancients, it was a long time before the present name was adopted. The name of the species is derived from the ancient Singhalese word turmali, and not turamali, which is applied by the natives of Ceylon to the yellow zircon of that island.

As the story goes, one warm summer's day early in the eighteenth century, some children of Amsterdam were playing with stones brought home by Dutch navigators and noticed the strange attractive powers developed by the exposure of the stones to the heat of the sun. Their parents, summoned to view the phenomenon, were likewise astonished to find that these stones could attract or repel, with a decided force, ashes, straws, and other light substances. The Dutchmen proceeded to call them aschentreckers, or "ash-drawers." Schorl, a subsequent title, afterwards gave way in favor of tourmaline.

MODE OF OCCURRENCE

Tourmaline occurs in compact or disseminated masses in rock and as loose, rounded crystals in secondary deposits. It is a common accessory mineral in pegmatites associated with granite intrusions, and also in metamorphic rocks, such as gneisses, schists, and crystalline limestones. The light-colored gem varieties are found chiefly in pegmatites. The minerals ordinarily found associated with tourmaline are orthoclase, albite, quartz, muscovite, lepidolite, beryl, apatite, fluorite, etc.

MINING METHODS

Generally, in mining for tourmalines, the rock is drilled by hand and the blasting is done with black powder in preference to dynamite, so as to minimize the risk of shattering the valuable gem material. Where a considerable thickness of schist overlies the pocket-bearing layer, tunneling is the most economical method of working. After the rock is broken, the tourmaline crystals are removed carefully by hand.

DOMESTIC PRODUCTION

The value of the production of tourmaline in the United States at one time was of considerable importance. During the period of 1902-1910, inclusive, the domestic production exceeded $30,000 annually and in 1909 the value of the output reached $133,192. The high mark reached during this peak year was attributed to trade with the Chinese merchants in pink tourmalines from California. Although subsequent years showed a decided decline, in 1916 the value of production reached the $50,000 mark. Production statistics for the United States from 1898 to 1921, when the United States Geological Survey discontinued the canvass of producers are given in the following table. Later figures are not available.

Table 1.- Value of tourmalines produced in the United States, 1898-1921[1]

Year	Value	Year	Value	Year	Value
1898	$4,000	1906	$72,500	1914	$7,980
1899	2,000	1907	84,120	1915	10,969
1900	3,500	1908	90,000	1916	50,807
1901	15,000	1909	133,192	1917	12,452
1902	30,000	1910	46,500	1918	6,206
1903	45,000	1911	16,445	1919	17,700
1904	40,000	1912	28,200	1920	4,869
1905	50,000	1913	7,630	1921	1,450

1/ Compiled from Annual Chapters of the Mineral Resources of the United States, Pt. II.

DEPOSITS IN THE UNITED STATES

In the United States, California and Main have been the chief tourmaline-producing States. These widely separated regions are both famous for their beautiful colored tourmalines. In Maine, are the deposits at Mount Mica, Mount Apatite, and Mount Rubellite near the towns of Paris, Auburn, and Hebron, respectively; while in California, the principal deposits are found in the Mesa Grande district in San Diego County.

Other localities in this country are Haddam, Conn.; Chesterfield and Goshen, Mass.; Gouverneur, De Kalb, and Pierrepont, N. Y.; and Chester, Pa. Deposits of lesser importance have been found also in several other States.

Arizona

Upon examination of the quicksilver deposits of Arizona, cinnabar was found closely associated with tourmaline. As cinnabar in so many of its occurrences has been deposited near the surface and at relatively low temperatures, and tourmaline is a mineral characteristic of pegmatite dikes and of veins belonging to the deep zone and formed at high temperatures, the occurrence of these two minerals in association was considered worthy of record. Lausen[3] has described in considerable detail the occurrence of tourmaline in the cinnabar veins of the Mazatzal Mountains of Arizona.

California

California tourmalines were known as early as 1872, when the Indians and cowboys gathered the crystals from the Mesa Grande region in San Diego County. After commercial exploitation took place, it was found that the tourmaline-bearing belt lies in San Diego and Riverside Counties and includes Mesa

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3 - Lausen, Carl, Tourmaline-bearing Cinnabar Veins of the Mazatzal Mountains, Arizona: Econ. Geol., Dec., 1926, pp. 782-791.

Grande, Pala, and Coahuila Mountain as the principal localities. Mesa Grande is by far the most interesting locality, being noted for pink and variegated tourmalines and for having yielded the large and magnificent groups now seen in some of the museums.

According to Foshag,[4] no other known locality produces tourmalines equal to the California specimens. While the California stones are inferior to the Maine (Mt. Mica) stones in beauty and color, they surpass them in size and crystal perfection. Many of the larger crystals exceed 5½ inches in length and 3½ inches in thickness, and a large number have been found with the crystal faces developed at both ends.

The California tourmalines rarely show concentric bands, although a few are green in the center and pink outside. The more striking forms are longitudinally banded. For instance, the wonderfully beautiful crystals from Pala are one-half deep pink with the remainder clear green. The larger crystals from Mesa Grande usually show a uniform pink capped with green, or sections of green, pink, and salmon.

In the Mesa Grande region in San Diego County, Calif., the mineral occurs also in pegmatitic rocks associated with spodumene, commercially known as kunzite, and occasional gem minerals of other varieties.

These different localities have been described by Kunz.[5]

At one time the trade with Chinese merchants in pink tourmaline from California had grown to quite a considerable industry. The estimated value of purchases by the Chinese during 1909 alone was close to $100,000, and during the summer of 1910, the Himalaya Mining Co., sold to these merchants a large consignment which consisted of 358,500 carats of pink tourmaline crystals ranging in size from 100 to 1,000 carats.

Maine

Mount Mica, which is situated about 1½ miles east of Paris, Me., is undoubtedly one of the most famous mineral localities in the United States. Since 1820, it has been known to mineralogists all over the world because of the size and beauty of its tourmaline crystals. A good description of this locality has been given by E. S. Bastin,[6] and the earlier history in detail was written by A. C. Hamlin.[7]

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[4] - Foshag, W. F., Gems and Gem Minerals: Smithsonian Sci. Ser., vol. 3, pt. 2, 1929, pp. 238-243.

[5] - Kunz, Geo. F., Gems, Jewelers' Materials and Ornamental Stones of California: California State Min. Bur. Bull. 37, San Francisco, June, 1905, pp. 54-63.

[6] - Bastin, E. S., Geology of the Pegmatites and Associated Rocks of Maine: U. S. Geol. Survey Bull. 445, 1911, pp. 81-93.

[7] - Hamlin, A. C., The History of Mount Mica: Bangor, Me., 1895, 72 pp.

A large number of unusually fine gems have been cut from the tourmalines of Mount Mica. Green is the predominant color of the gem tourmalines, but this district has yielded fine rubellite, indicolite, and achroite gems of varying hues. The colorless achroite crystals grade into delicate pink, green, and blue; the indicolites are greenish blue and nearly sapphire blue; and the rubellite runs from pale to deep pink and nearly ruby-red. The combinations of these various colors in a single crystal, have furnished some very remarkable specimens for mineral collections now scattered through many parts of the world.

The Mount Apatite district also has yielded some very fine gem crystals. A number of quarries were opened for feldspar and tourmaline on Mount Apatite about $3\frac{1}{2}$ miles west of Auburn, Me., from which pockets were discovered which yielded some very fine colored tourmalines. One quarry on the west side was worked by W. R. Wade,[8] and has been described along with other gem deposits of Maine. Besides those found and described by Wade, other pockets with purple apatite have been unearthed, but such crystals have been sold chiefly for cabinet specimens, because owing to the comparative softness of apatite they would not wear well if cut into gems.

FOREIGN LOCALITIES

Tourmalines[9] and especially rubellites (which are found in all colors) occur in nearly every country of the globe but rarely in sufficient quantities to mine.

Magnificent crystals of pink, blue, and green have been found in the neighborhood of Ekaterinburg, principally at Mursinka, in the Urals, Russia, and fine rubellite has come from the Urula River, and other spots near Nertschinsk, Transbaikal, Asiatic Russia. Elba, the Italian island on which Napoleon was exiled, produces pink, yellowish, and green stones, frequently particolored, and sometimes the crystals are blackened at the top and are called "nigger heads." Ceylon supplies small yellow stones which are often confused with zircon of a similar color. Rubellite accompanies the ruby of Ava, Burma, and rivals the ruby itself in color.

In Canada, amber-colored crystals are found at Fitzroy, Ontario; transparent brown at Hunterstown, Quebec; black at Bathurst and Elmsley, Ontario and St. Jerome, Quebec; and magnificent green-yellow crystals occur in the limestones at Great Calumet Island. Fine tourmalines in a great variety of colors, and frequently zoned are found at many localities in Madagascar. These stones compare favorably in beauty, if not in size, with any found elsewhere. Tourmalines are found in Siberia and Sweden also, and to a lesser extent in many localities; but, Brazil is undoubtedly the greatest tourmaline country.

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8 - Wade, W. R., The Gem-bearing Pegmatites of Western Maine: Eng. and Min. Jour., vol. 87, 1909, pp. 1127-1129.

9 - Pan American Union Bulletin, The Semiprecious Stones of Brazil: Washington, April, 1925, pp. 371-377.

Brazil

To-day Brazil is by far the most important source of tourmalines. Practically all the tourmalines mined in Brazil are from the state of Minas Geraes near the border of Espirito Santo, and the city of Lajao is the most important mining center. Rubellite is the most common variety and exists in all colors.

In the Brazilian stones the core is generally red, bounded by white, with green on the exterior. However, beautiful crystals of green and red, often diversely colored, come from various parts of the State of Minas Geraes, Brazil. According to A. S. Atkinson,[10] as far back as 1909 tourmaline mining has been one of the most important industries in Brazil. In view of the fact that precious stones are so profuse in Brazil and semiprecious stones are found in such large quantities, it is not surprising to note that this country ranks first among the tourmaline sources of the world.

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[10] - Atkinson, A. S., Mining for Gems in Brazil: Eng. and Min. Jour., vol. 87, June 19, 1909, p. 1234.